

***SPAtially Referenced Regressions
On Watershed Attributes
(SPARROW)
to Support the
Management of Nutrient Loading to
Chesapeake Bay***

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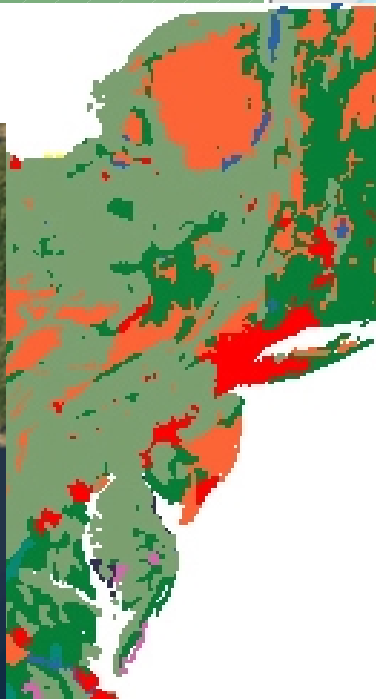
U.S. Geological Survey
Baltimore, Maryland



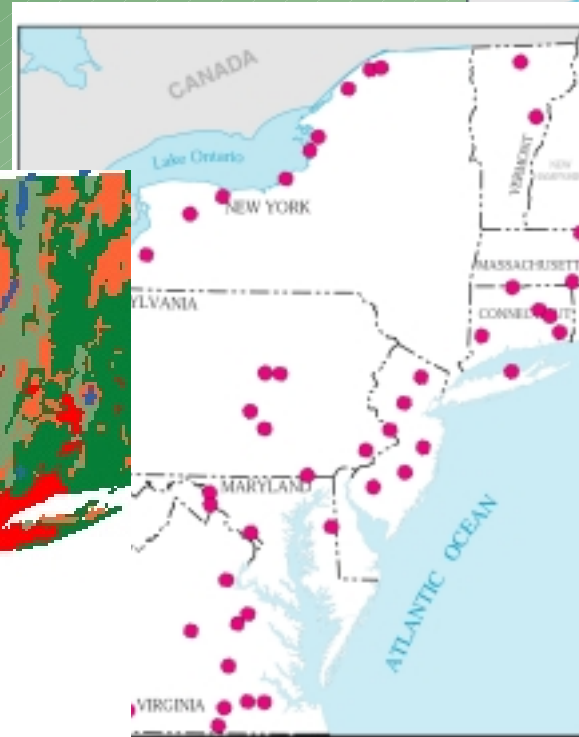
Integrates watershed data
over multiple spatial scales
to predict origin & fate of
contaminants

SPARROW (SPATially Referenced Regression on Watershed Atttributes)

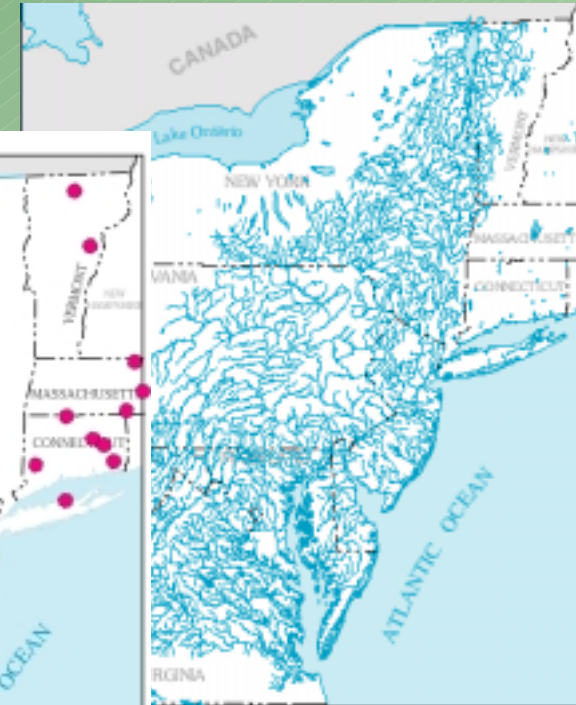
Landscape
Features



Land Use &
Sources



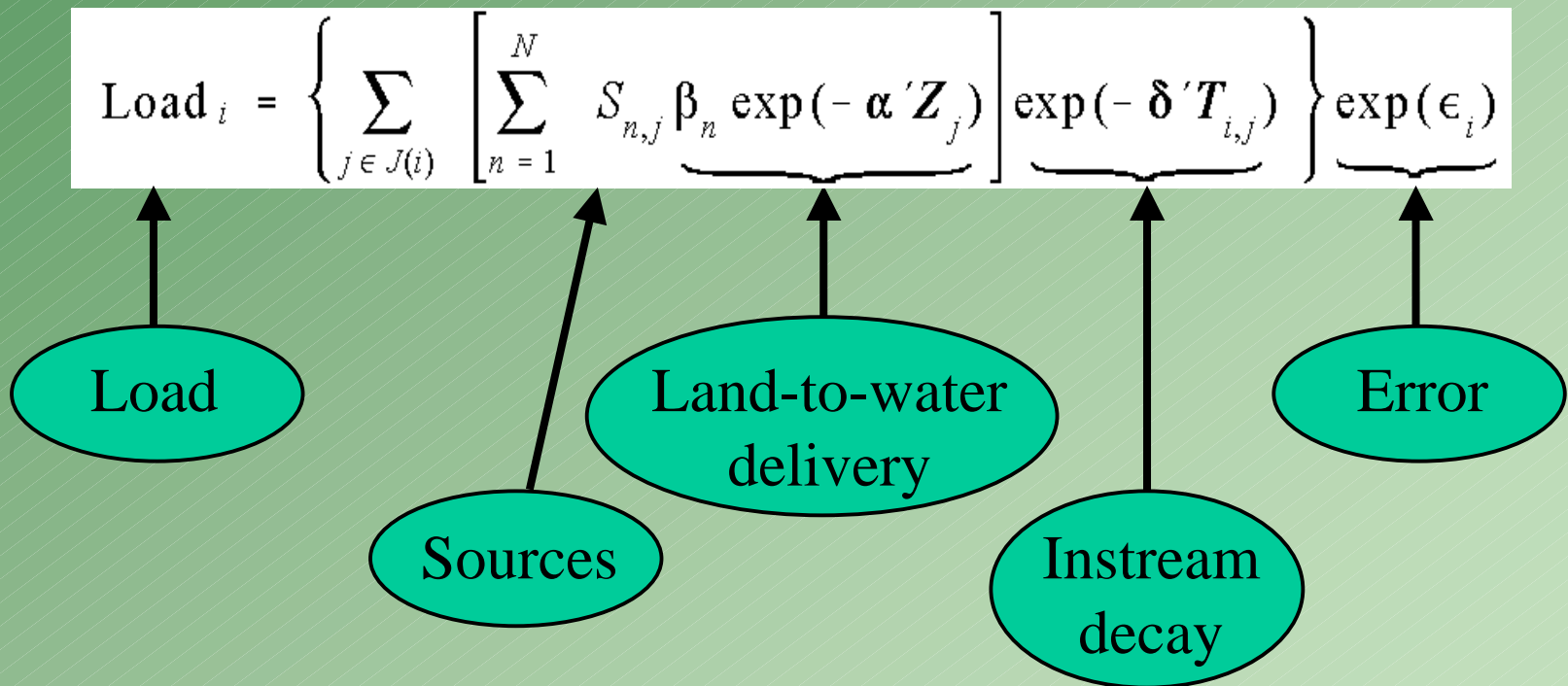
Monitoring Data



Drainage &
Impoundments

SPARROW

Estimated Equation

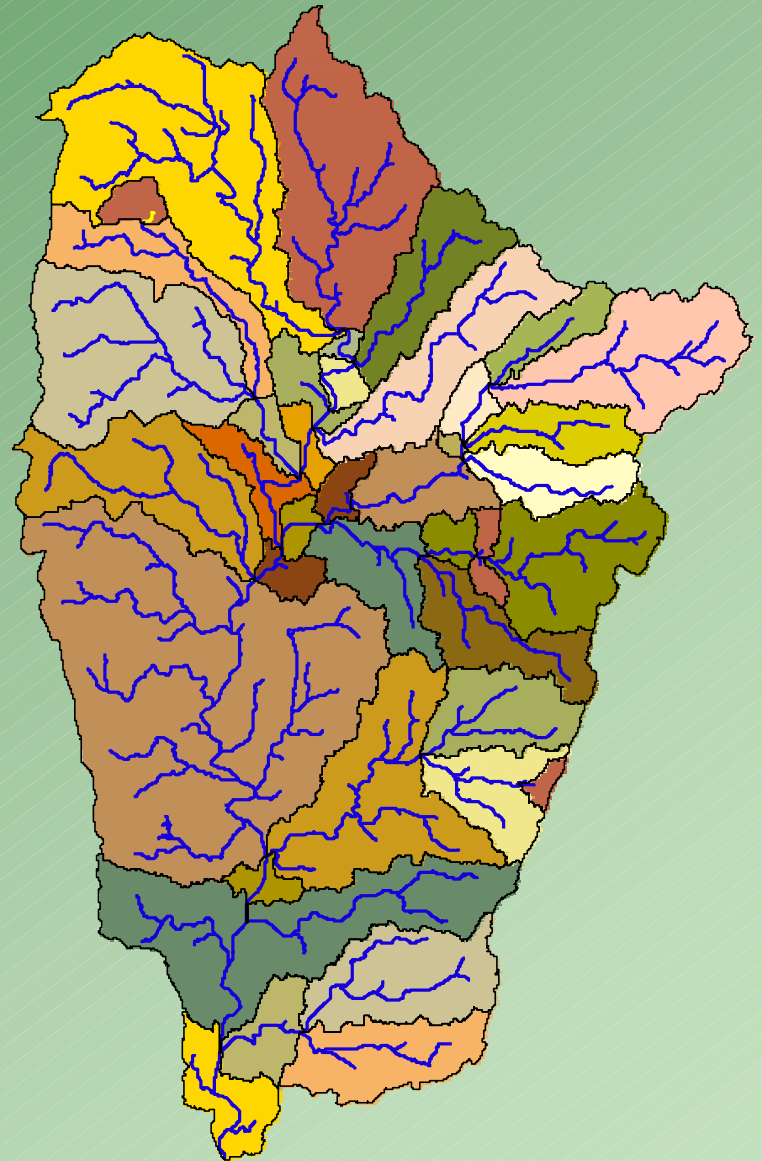
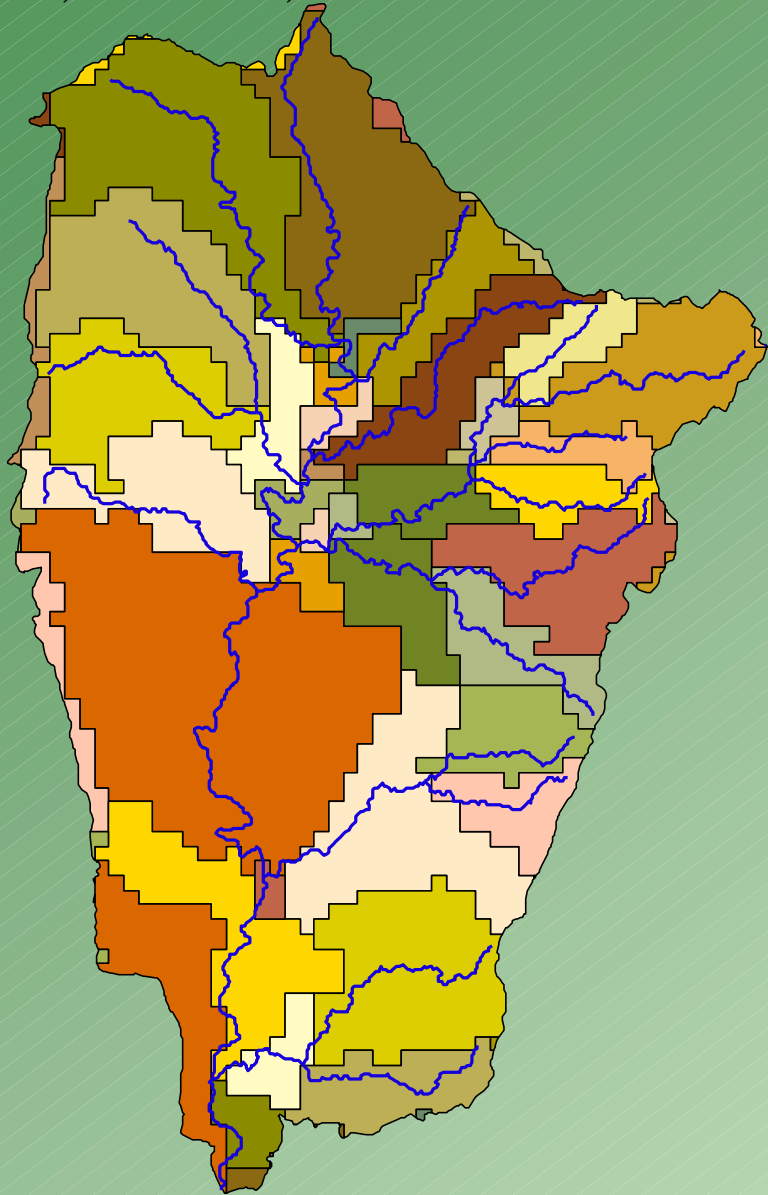


SPARROW'S DATA COMPONENTS

- * Network - Including Stream Network and Basin Segmentation
- * Dependent Variable - Stream Loading Information
- * Nutrient Sources - Point Source, Nonpoint Source, Atmospheric Deposition, Others
- * Delivery Factors - Soils, Slope, Physiography, Geology, Meteorology, Others

Network, 1K DEM, 500k Reaches

Network, 30m DEM, >5000 cells per Reach



Monocacy River Basin

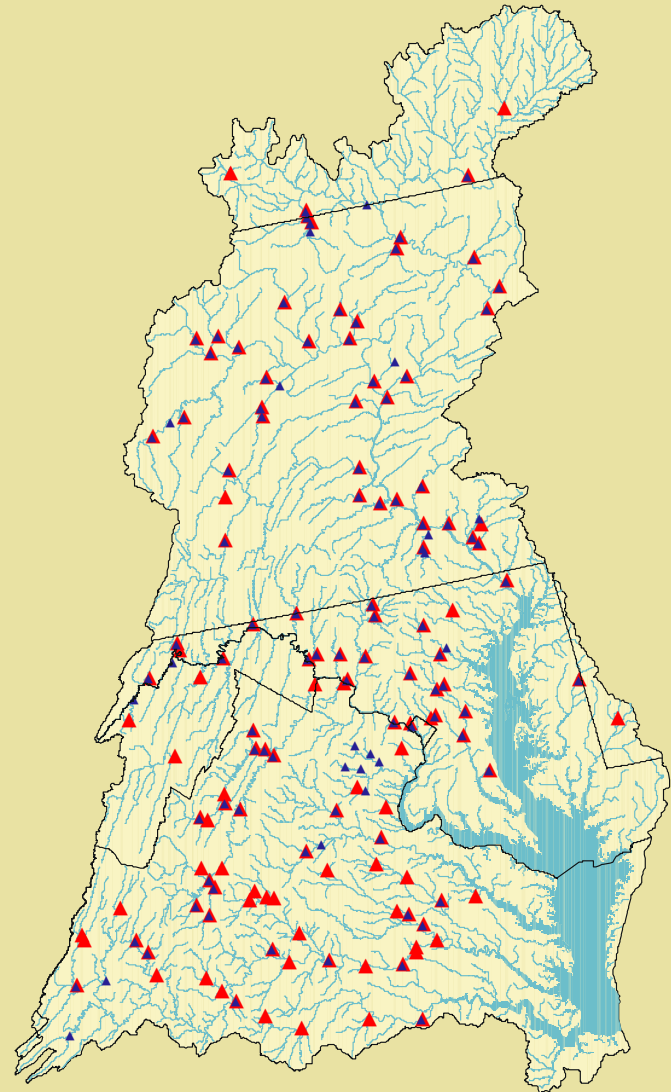
Chesapeake Bay SPARROW

Version II

Enhanced Stream-Load
Data Base

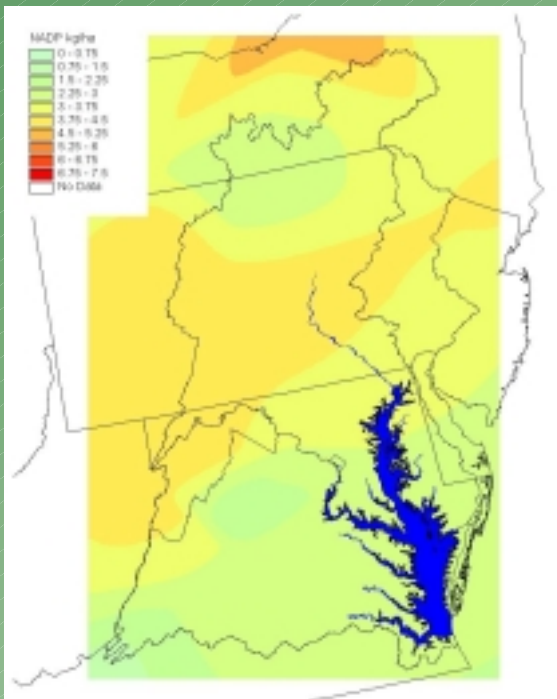
▲ Version I - 1987

▲ Version II - 1992

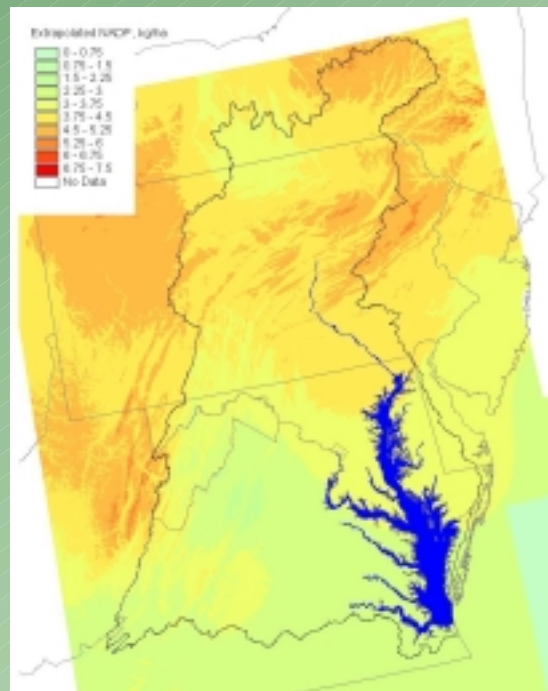


Nitrate Wet-Deposition Data Sets Chesapeake Bay Region

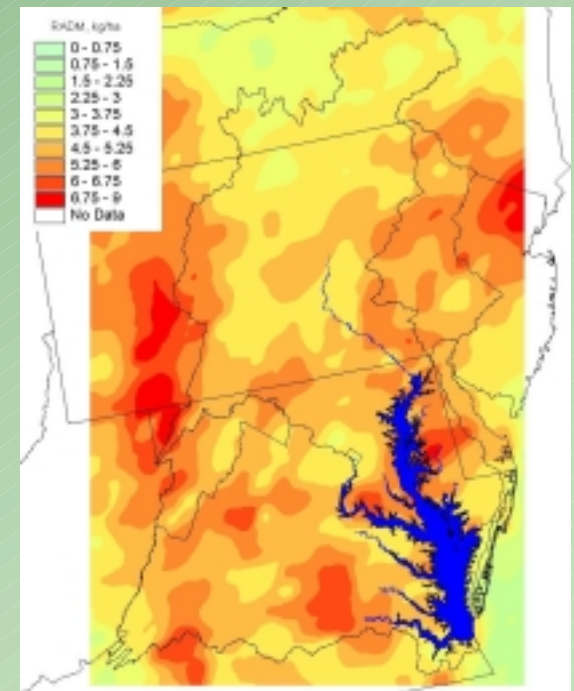
Interpolated
NADP
Data



Penn State
Modeled
NADP Data



RADM
Model



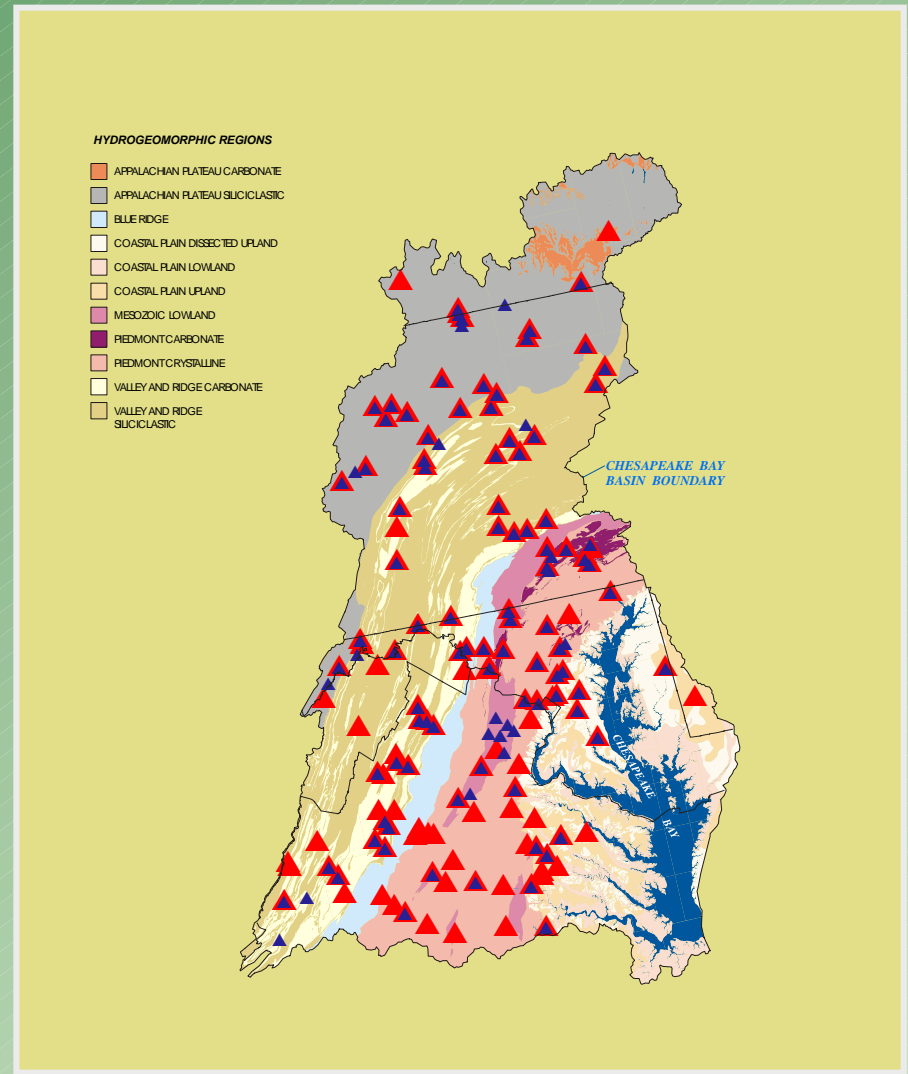
Chesapeake Bay SPARROW

Version II

HGMR / Load Site
Distribution

▲ Version I - 1987

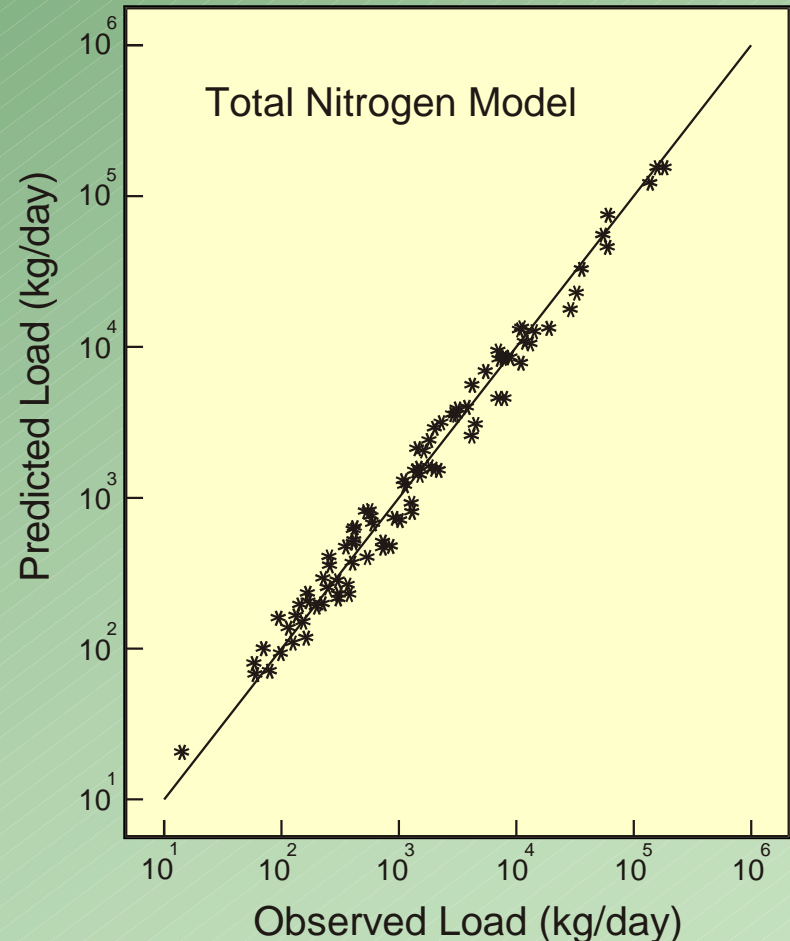
▲ Version II - 1992



Chesapeake Bay SPARROW

Total Nitrogen Model - Calibration Results

Explanatory Variables	Parameter Estimates	Prob > T
Nitrogen Sources (β)		
Point sources (kg/yr)	2.04	<0.005
Septic Tank (kg/yr)	0.598	0.083
Urban area (ha)	14.9	<0.005
Fertilizer application (kg/yr)	0.373	<0.005
Manure application (kg/yr)	0.287	<0.005
Atmospheric deposition (kg/yr)	0.317	<0.005
Land to water delivery (α)		
Temperature ($^{\circ}\text{F}$)		
Precipitation (in)		
Average slope (%)		
Coastal Plain Area (%)	0.454	0.002
Soil permeability (in/hr)		
Stream density (1/mi)		
Wetland (%)		
Instream loss (δ)		
T_1 ($Q < 200 \text{ ft}^3/\text{s}$)	0.640	<0.005
T_2 ($200 \text{ ft}^3/\text{s} < Q < 1,000 \text{ ft}^3/\text{s}$)	0.201	0.104
T_3 ($Q > 1,000 \text{ ft}^3/\text{s}$)	0.004	0.940
T_3 (reservoir retention)	0.463	0.043
R-squared	0.977	
Root mean square error	0.308	
Number of observations	88	

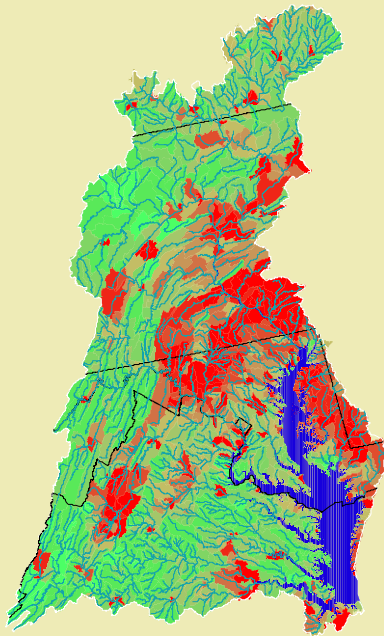
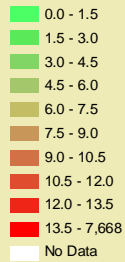


Chesapeake Bay SPARROW

Predicted Total Nitrogen Yield

Incremental Yield

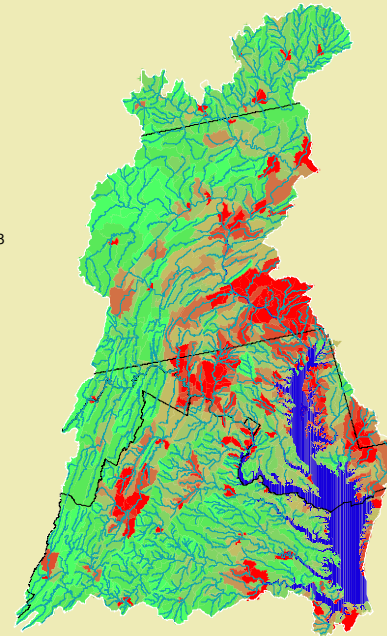
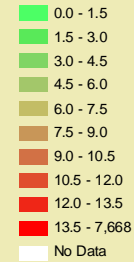
kg/ha/yr



0 20 40 60 80 100 Miles

Delivered Yield

kg/ha/yr

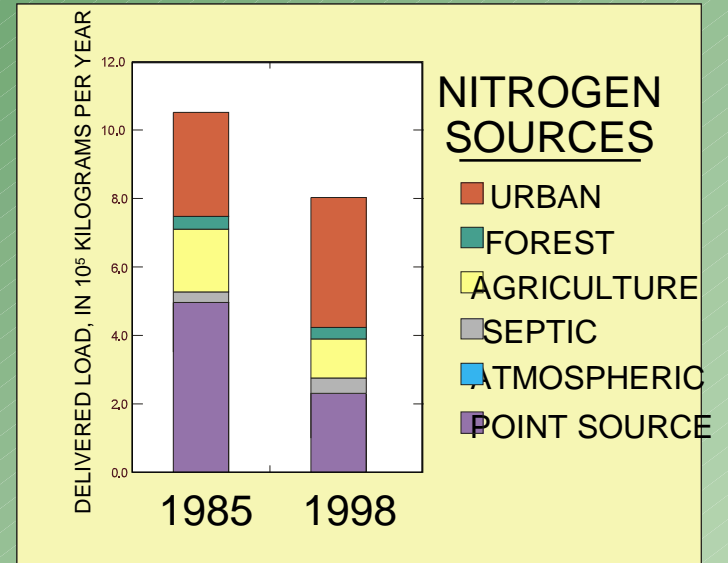
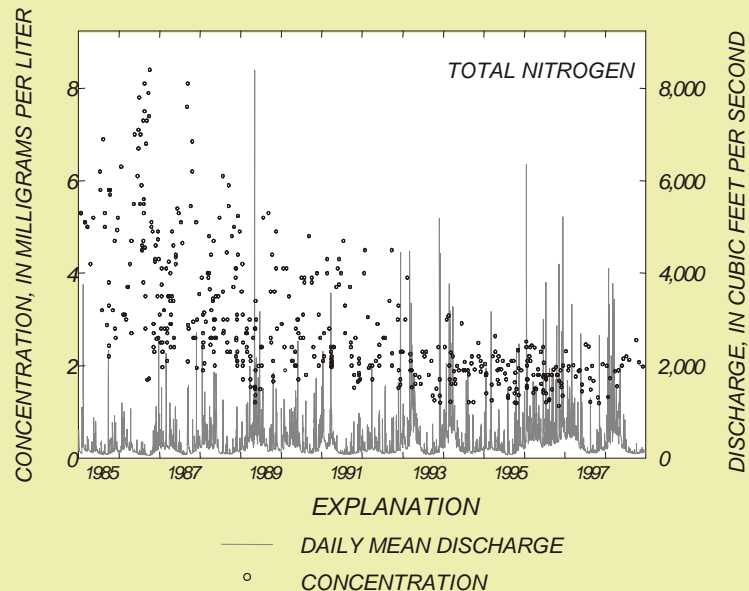


0 20 40 60 80 100 Miles

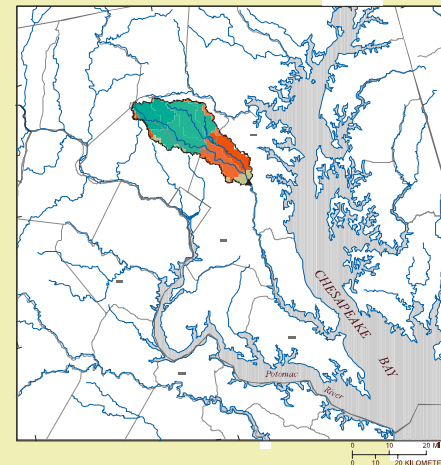


Factors Affecting Nutrient Trends In Major Rivers of the Chesapeake Bay Watershed Sprague and others (2000) WRIR 00-4218

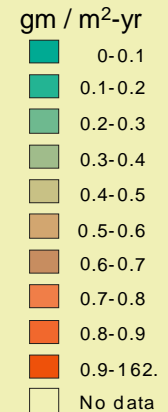
Patuxent River



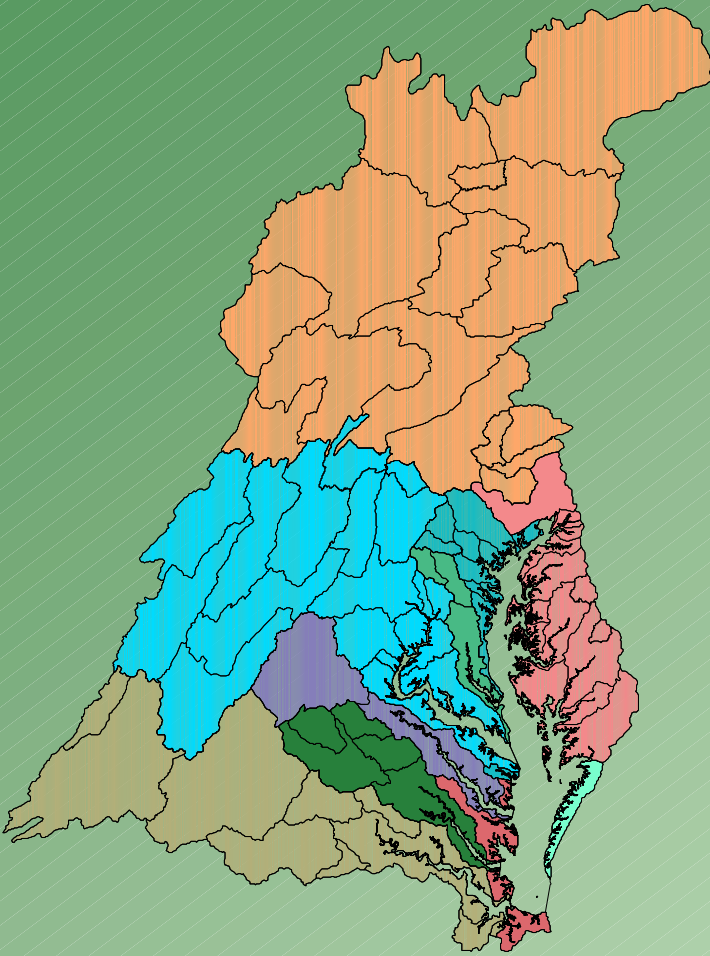
Patuxent River Basin



Total Nitrogen Delivered Yield



Chesapeake Bay Program Watershed Model - HSPF



Limitations of Modeling Framework

- Over-Parameterized
- Labor-Intensive Manual Calibration
- Spatial Coarseness
- No Systematic Method of Assessing Error

Why is HSPF Necessary?

- Designed for Studying the Relations of Human Activities on the Landscape to Nutrient and Sediment Loads of Streams
- Allows Simulation of “ALL” Human Activities that Affect Stream Loads
- Allows the Simulation of Management-Practices to Assess Their Effectiveness and Optimize the Efficient Use of Resources

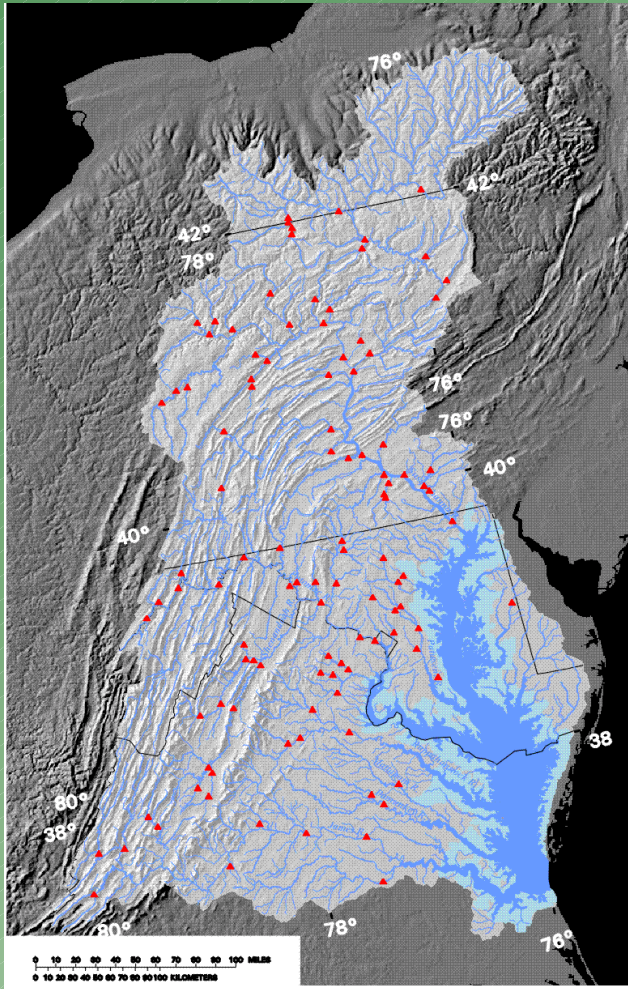
U.S. Geological Survey - SPARROW

Description of Modeling Framework

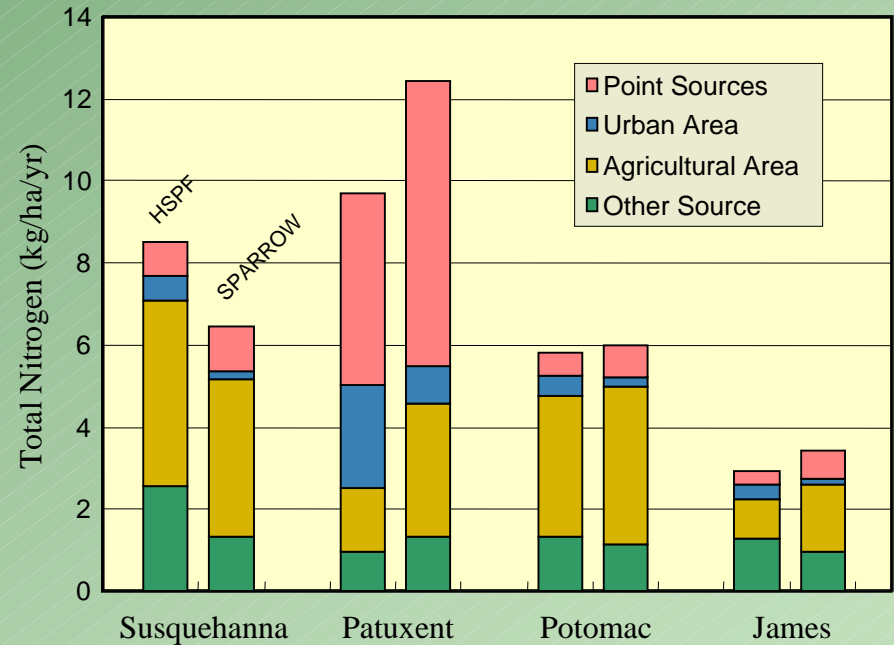
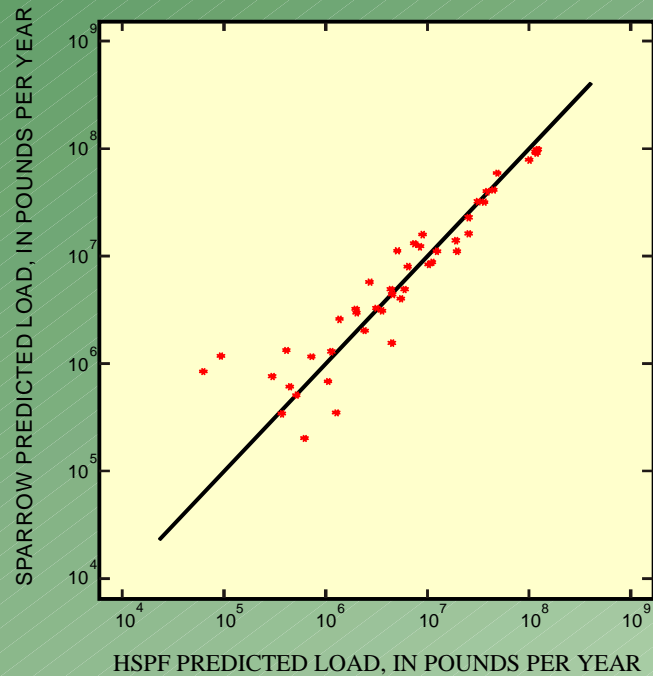
- Statistical
- Designed to Define Spatial Relations Between Contaminant Sources and Stream Loads
- Spatially Defined Only
- Spatially Detailed

Chesapeake Bay Application

- Provide Framework for Relating Various Types of Detailed Geographic Data to Stream Nutrient Loads
- Statistically Identify the Environmental Factors that are Most Closely Related to Stream Loads
- Provide Spatially Detailed Estimates of Stream Load for Targeting and Other Uses

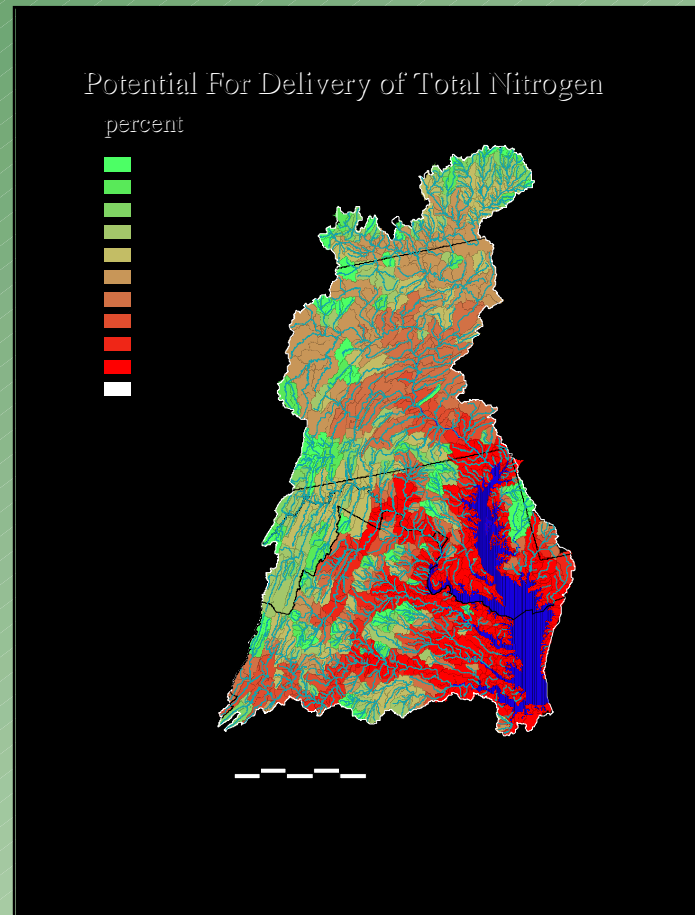


Chesapeake Bay Watershed SPARROW / HSPF Comparison



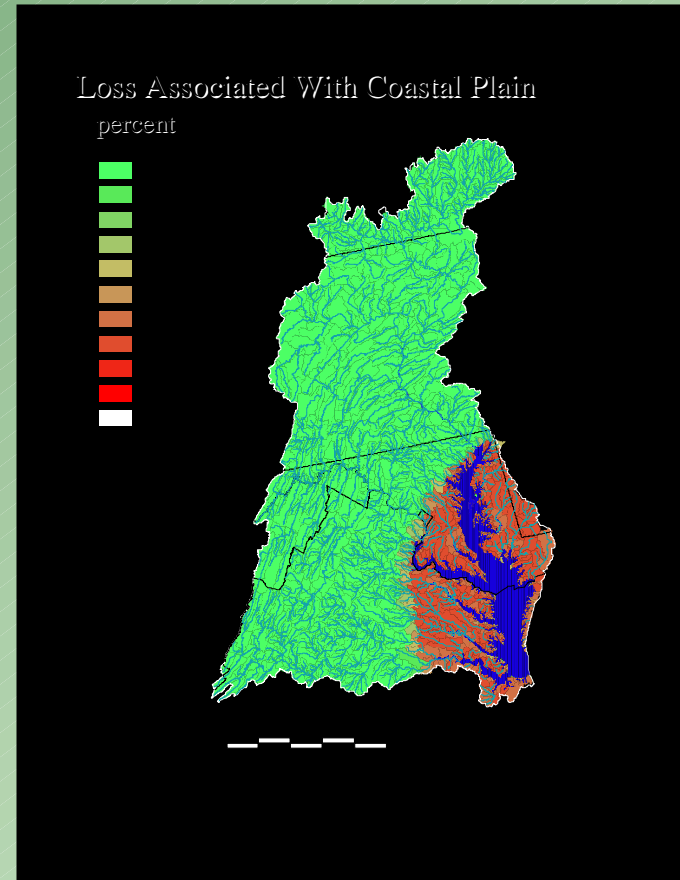
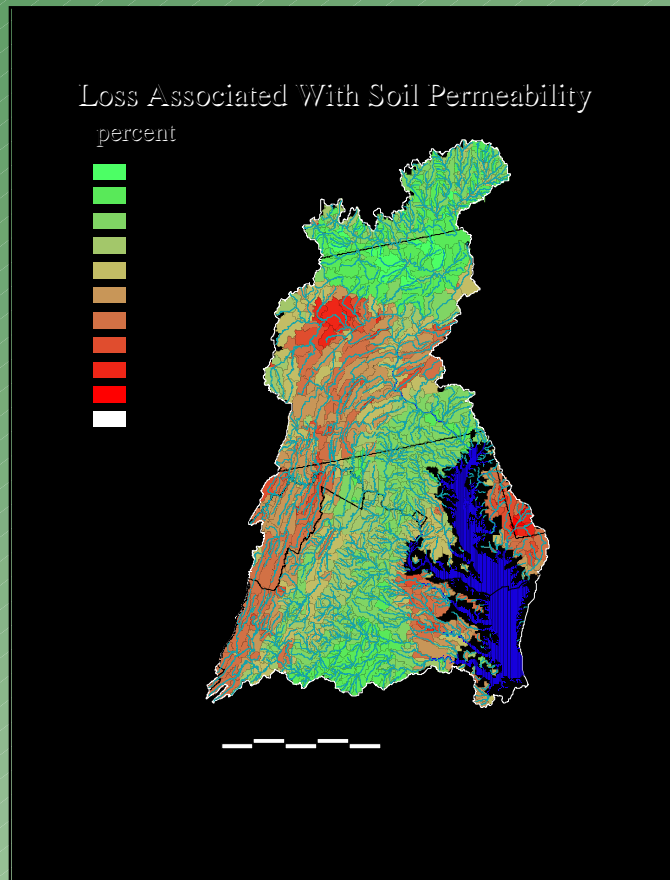
Joint Application of SPARROW and HSPF

Model Feedback - Instream Loss Rates



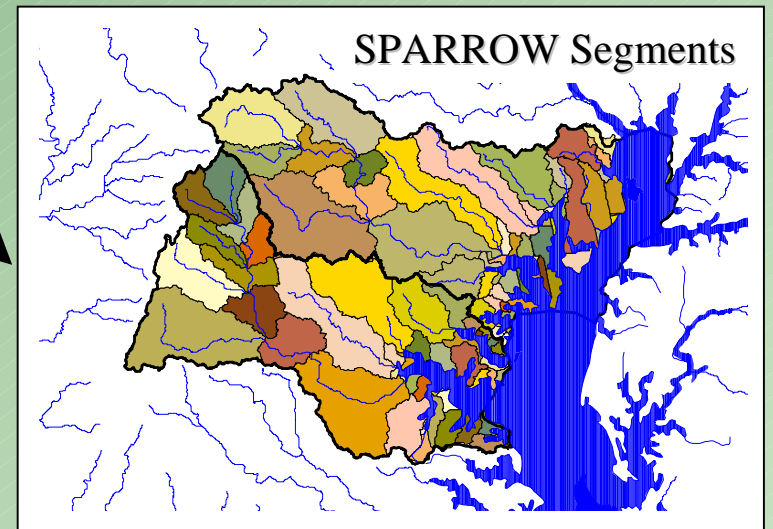
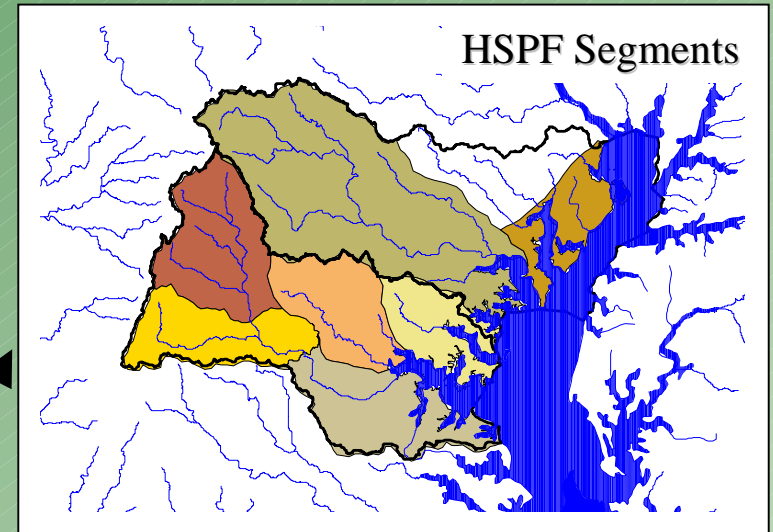
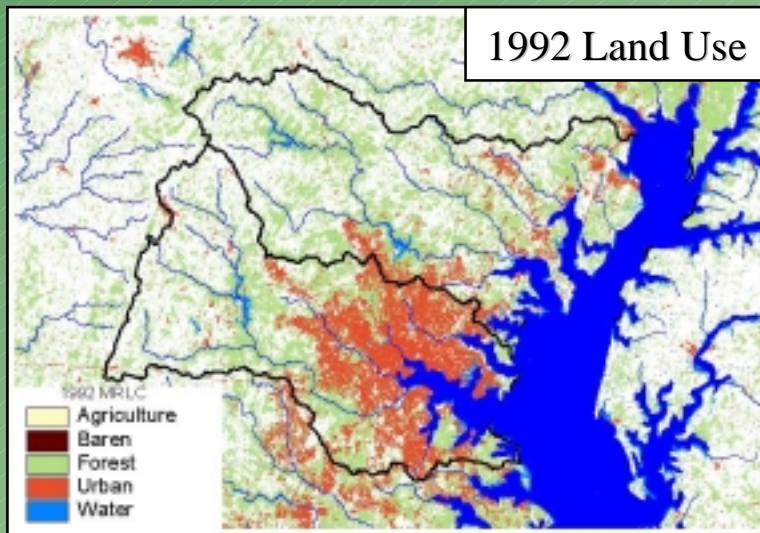
Joint Application of SPARROW and HSPF

Model Feedback – Identification of Significant Variables



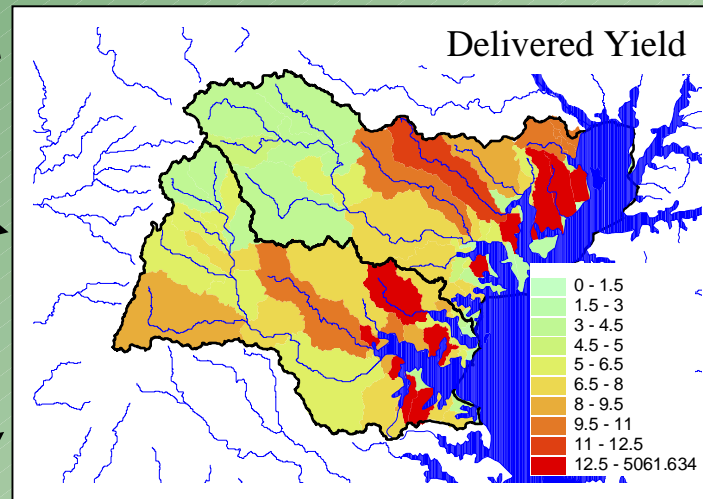
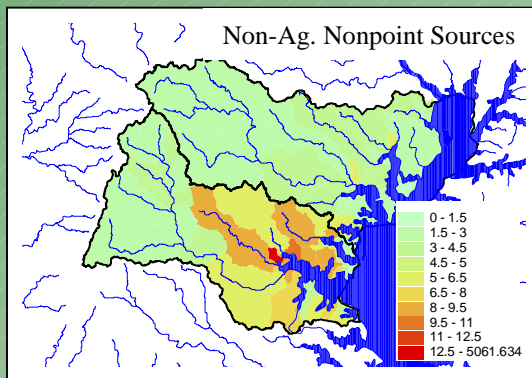
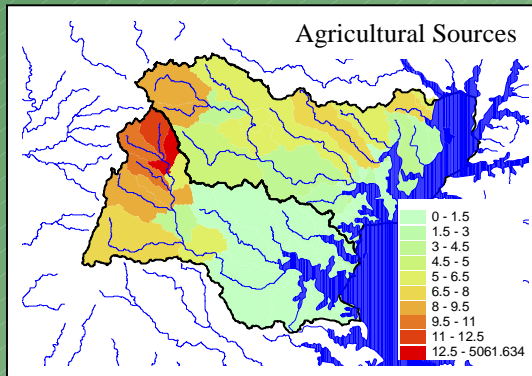
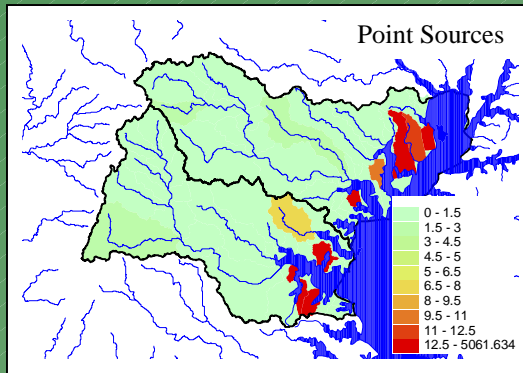
Joint Application of HSPF and SPARROW

Targeting – Area Specific
Management Plans



Joint Application of SPARROW and HSPF

Targeting – Area Specific Management Plans



Management Scenario

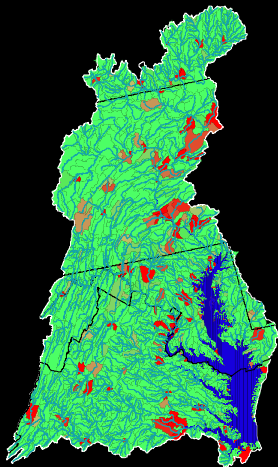
Test With HSPF

Joint Application of SPARROW and HSPF

Targeting – Basin-wide Allocation Process

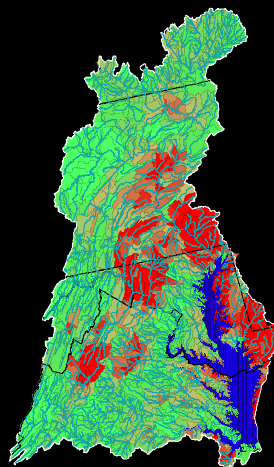
Delivered Yield - Point Sources

kg/ha/yr



Delivered Yield - Agricultural Sources

kg/ha/yr



Delivered Yield - Nonpoint Sources

kg/ha/yr

